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During the period from 1970 to 1975, under this federally funded project, a major portion of the paint research has been on traffic line paints. This report describes work done on rapid dry hot applied and fast dry cold applied traffic paint formulations, their improvement, and efforts to reduce raw materials costs.

This report also describes the development or modification of specifications for concrete curing compounds, zinc rich primers for structural steel, flame spray traffic lines, vinyl wash primer and rapid dry equipment enamel. Preliminary work on water based paints is also described.

A report on a series of laboratory tests for comparing effectiveness of five coating materials for protecting bridge deck concrete against damage by deicing salts is also included.

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STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF STRUCTURES & ENGINEERING SERVICE
OFFICE OF TRANSPORTATION LABORATORY

December 1976
TL No. 635135
Item No. D-5-35

Mr. C. E. Forbes
Chief Engineer:

Dear Sir:

I have approved and now submit for your information this final research project report titled:

COATINGS, SEALANTS AND PAVEMENT MARKERS

Study made by . . . . . Roadbed and Concrete Branch

Under the Supervision of . . . . . D. L. Spellman

Principal Investigator . . . . . Thomas L. Shelly

Co-Principal Investigator . . . . . Donald R. Chatto

Report Prepared by . . . . . Donald R. Chatto
Robert W. Ford
Raymond Warness
Bill J. Chapman

Very truly yours,

George A. Hill

GEORGE A. HILL
Chief, Office of Transportation Laboratory

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Mr. Enrico Maggenti, who assisted in laboratory and field evaluations.

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We wish to also thank the representatives of many paint manufacturers and raw materials suppliers for their advice, assistance and cooperation.

This project was performed in cooperation with the U. S. Department of Transportation, Federal Highway Administration, Agreement No. D-5-35.

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California, or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

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INTRODUCTION

In July, 1970, the Federal Highway Administration gave approval for federal financing to continue research on paints. Until about 1972 most effort was devoted to the development of protective coatings for steel bridges. More recently the major work has been the development of paints for traffic lane delineation including flame spray granules. Other phases of this project include concrete curing compounds, treatments for freeze-thaw protection of concrete, and water based paints.

Under this project selected commercial products were tested, new paints were formulated and evaluated through laboratory tests and field trials, and State of California specifications were written.

This report together with two reports (1) and (2) listed under references completes this research project.

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CONCLUSIONS

State of California formulation type specifications have been developed for fast-drying and rapid-drying traffic line paints. Under road conditions the drying times are five minutes for the fast drying type, one minute for the rapid drying type when applied without heat, and about 30 seconds when heated to 80°F (27°C) or higher. Raw material costs of traffic line paints have been reduced and a start has been made in improving retention of reflective beads in the paint film.

A zinc-rich primer for structural steel has been developed to replace formulations containing lead.

Petroleum hydrocarbon resin base and chlorinated rubber base concrete curing compound specifications have been developed to replace wax-base compounds. The formulations have been modified to lower raw material costs, and for special applications, e.g., use on New Jersey barriers.

Laboratory tests of five materials proposed for protecting bridge concrete against freeze-thaw damage where deicing salts are used showed that a 50 percent solution of linseed oil in kerosene is superior to three commercial waterproofing products and a chlorinated rubber base paint.

Preliminary formulations of water base paints tested to date do not protect structural steel against salt spray and moisture as well as the better solvent base paints now in use, but they do show promise.

Research for improving the working properties and reducing the raw material costs of paints used in highway construction should continue.

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IMPLEMENTATION

The following specifications have been developed during this project and are in use now either for construction and/or maintenance:

Vinyl Wash Primer	701-80-52
Organic Zinc Rich Primer	741-80-62
Tinted Translucent Acrylic	741-80-15
Syrenated Alkyd Enamel	711-80-151
Rapid Dry Traffic Paint White	Pt 400
Rapid Dry Traffic Paint Yellow	Pt 401
Fast Dry Traffic Paint White	Pt 361
Fast Dry Traffic Paint Yellow	Pt 362
All Purpose Black Traffic Paint	Pt 235
Curing Compound Resin Based	721-80-71
Curing Compound Chlorinated Rubber, White	721-80-100
Curing Compound Chlorinated Rubber, White and Gray	721-80-101
Curing Compound Chlorinated Rubber, Clear	721-80-102
Thermo-Applied Striping Granules	702-80-29
Thermoplastic Traffic Line	761-80-31

Copies of these specifications in a form which does not list brand names of the components may be obtained upon request to the:

Office of Transportation Laboratory
5900 Folsom Boulevard
Sacramento, California 95819

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TRAFFIC LANE DELINEATION

Under this project considerable work has been done on the development of materials for traffic lane delineation. The emphasis has been largely on reducing material costs and decreasing dry time while maintaining adequate durability and nighttime visibility. The earlier work reported in the interim report "Coatings and Pavement Marking Materials, 1969-1972", D-5-35, August 1972(1), covers the work done in reducing the drying time of conventional traffic paints and the development of thermoplastic traffic line and flame-sprayed striping granules.

Another interim report "Development of Specifications for Hot and Cold Applied Traffic Paints", D-5-35, September 1975(2) discusses the formulation of a traffic line paint that would dry within 30 seconds after applying at 200°F (93°C) and a formulation that dries without heating within 5 minutes. It also covers the development of methods to determine dry paint film thickness and bead content of a traffic line at the time of application to the road.

This portion of the final report covers the work done during the period 1974-75 on California Rapid Dry Hot Applied and Fast Dry Cold Applied, Traffic Paints. This work is a continuation of work reported under the title "Development of Specifications for Hot and Cold Traffic Paints", reported in September 1975, Report No. D-5-359(2).

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RAPID DRY TRAFFIC PAINTS

In 1972 California designed and built 11 striper units with the capability of heating traffic paint up to 240°F. These units were equipped with high pressure airless applicator guns and pressurized post-applied glass bead applicators. Since no open flame or gas fired heat exchangers were employed in these units, the heating of the highly flammable traffic paint was reduced to a relatively safe operation. The heating unit, somewhat similar to a torque converter is revolved at very high speeds, which converts the expended mechanical energy directly into heat energy. This allows the paint to be heated on a continuous basis, and maintaines the temperature within ± 2°F by electronic controls which govern the speed of the heater unit shaft. To achieve dry times of 30 seconds or less, it was necessary to heat the paint to 180°F to 200°F in the heater. The high speed required to attain this temperature caused shaft seal problems that have plagued these stripers for 3 years. When the shaft seal is broken, the heater becomes inoperative due to paint leakage from the seal. Various different seal arrangements have been tried but still the problem persists. If the heater were run at lower speeds there would be less strain on the seal and less heat produced. If dry times were to be kept under 1 minute with lower heat then the traffic paint itself would have to be reformulated.

Also influencing the need to reformulate the rapid dry paint was the continuing high prices of raw materials. This necessitated a more critical approach in the use of raw materials.

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1. Examination of Surface Drying Characteristics

a. ASTM Method D711

This procedure has been the standard for measuring the dry time of traffic paint for many years and has provided a convenient and fast method to evaluate the dry time in the laboratory.

We have observed, and probably others have also, that this method sometimes does not correlate with drying times observed when traffic crosses a freshly painted line. The no-track time on the road sometimes is considerably longer than that found in the laboratory, especially when testing paints with drying times of 5 minutes or less. With chlorinated rubber vehicles, this condition is especially noticeable since this type of paint skins over rapidly forming a cushion for the ASTM wheel to ride over, thus protecting the underlying wet surface which gives a false (too short) drying time.

This can be illustrated by examination of previous rapid dry formulations as reported in the Table 1.

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TABLE 1

Formula Number	Dry Time* ASTM, Seconds	Road Surface Temp, °F	Paint Temp. °F	No-Track Time, Seconds	Dry Paint Thickness, In.
Pt 56A	60	80	152	90	0.005
		73	200	60	0.008
		72	235	30	0.007
Pt 89	45	68	150	60	0.008
		68	200	60	0.008
		68	220	30	0.008
Pt 97	30	73	200	20	0.008
		55	180	30	0.009
		100	200	30	0.008
Pt 143	45	99	180	60	0.008
		80	200	30	0.008

*ASTM D-711, without beads. Wet draw down .015 inches or 0.008 inches dry paint. Ambient, surface and paint temperature 77°F (27°C).

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From Table 1 it is illogical that PT 56A for example could have an ASTM dry time of 60 seconds and yet when applied through a striping machine at 152°F would give a no-track condition of 1 1/2 minutes at a dry film thickness of 0.005 inches. If PT 97 gives a 30 second ASTM dry time, then why should 200°F paint temperature be required to dry the paint on the road to a no-track condition in 30 seconds? It would appear that the ASTM method measures primarily the drying rate of the surface of the paint film.

b. Other Methods

In an effort to get better correlation between ASTM and actual road no-track dry time, two other rather simple tests have been run in conjunction with the ASTM dry time. Both these tests we believe give a better indication of the true drying rate of the whole paint film and not just the top surface. Both tests are performed on the same draw down film on glass plate as in the ASTM test.

The first test we designate as "Dry Under" time, and consists simply of carefully drawing back a small portion of the surface skin and noting the appearance of the paint film underneath. If it is still wet and glossy, the film still has considerable unevaporated solvent. The film is examined in the above manner at timed intervals and the time noted when the subsurface film shows a dull appearance, indicating most of the solvent has been released. This time is noted as "Dry Under" time.

The second test done on the same paint film is called the "Dry Thru" time and is similar to ASTM D1640 except that very light thumb pressure is used. The film is tested using very light thumb pressure and the dry thru time is taken at that point when light thumb pressure turned through a 90° angle does not break the paint film. This test also seems to indicate the film strength as well as dry time. Table 2 shows the "Dry Thru" and

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"Dry Under" test results of tests on various paints as compared to the ASTM method.

c. Comparison of Various Dry Time Methods

TABLE 2

Paint	Type	ASTM Minutes	Dry Under Minutes	Dry Thru Minutes
731-80-95	White Regular Dry	8	5	25
731-80-98	Yellow Regular Dry	8	5	21
711-80-195	White Fast Dry	8	9	18
711-80-198	Yellow Fast Dry	8	9	17
Bauer 1612A9	White Fast Dry	3	8	17
Bauer 1364A9	White Rapid Dry	3	4	10
Pt 56A	White Rapid Dry	1	9	19
Pt 89	White Rapid Dry	0.75	8	15
Pt 97	White Rapid Dry	0.50	5	13
Pt 143	White Rapid Dry	0.75	5	10
Pt 225	White Fast Dry	5	5	10
Pt 226	Yellow Fast Dry	6	6	10
Pt 400	White Rapid Dry	2	3.5	6
Pt 401	Yellow Rapid Dry	2	3	6

All paints .015 inch thick, wet, at 77°F ambient and paint temperature.

As can be observed from the table some widespread differences exist between ASTM dry times and the "Dry Under" and, more pronounced, the "Dry Thru" times. Pt 56A for example dries in 1 minute ASTM, yet takes 19 minutes for the "Dry Thru" time and Pt 97 with a 30 second ASTM takes 13 minutes to "Dry Thru". The Pt 400 and Pt 401, the current prototype rapid dry, poses quite a contrast with a 2 minute ASTM and a 6 minute "Dry Thru". The

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Pt 400 has shown no-track times on the road of 1 minute and less when cold applied and it is believed that the 6 minute "Dry Thru" time predicts this better than the ASTM wheel.

These two expressions of dry time will be referred to in this report when comparing the dry time of new formulations.

These methods are somewhat empirical but will be examined in more detail when further work is done on the traffic paint formulas.

2. Drying Properties of Various Rapid Dry Systems

a. Straight Alkyd and Alkyd Chlorinated Rubber

Paints were made starting with an all alkyd vehicle (Reichhold P660-60) with no chlorinated rubber and the drying parameters determined as described previously. Pigmentation for the formulas listed in Table 3 consisted of 50 lbs TiO_2, 50 lbs T-70 Micro Cell, and equal parts by weight of Talc and $CaCO_3$ to make 100 gals of paint.

TABLE 3

Alkyd	MEK	225 Thinner	Toluene	Chlorowax	Dry Time Minutes ASTM	Under	Thru	Vis. KU	Chlorinated Rubber 5 cps
200	133	133	62	-	12	7	12	61	-
175	133	133	-	25	7	3	11	68	25
150	133	133	-	25	5	2	10	75	50
150	133	133	-	25	3	3	10	77	75
150	133	133	-	25	1 1/2	3	9	80	100

The straight alkyd formula with 200 lbs alkyd per hundred gallons paint, drys too slow to be considered a rapid dry paint. Decreasing the alkyd and adding increments of 5 cps Parlon shows a rapid decrease

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in the ASTM dry time, due to more pronounced initial top drying of the paint film and the formation of a top skin. With chlorinated rubber vehicles the pigmentation must allow the film to breathe, especially with higher levels of chlorinated rubber. The T-70 microcell, synthetic calcium silicate, serves this purpose well. We see that with this alkyd resin, the level of chlorinated rubber required to make a rapid dry paint is around 100 lbs/100 gal and the previous formula for Rapid Dry (Pt 143) contained too high a level (173 lbs/ 100 gal).

b. Chlorinated Rubber Viscosity Grades

The 3 grades of chlorinated rubber, 5 cps, 10 cps, and 20 cps will, of course, produce different viscosities in the paint vehicle. To determine if the viscosity grade influenced the dry time, 3 paints were made using the different grades. A marked difference was found in the drying times of the paints. The 20 cps grade was found to give the fastest dry time as shown in Table 4:

TABLE 4

	Alloprene 20	Alloprene 10	Alloprene 5
Viscosity, KU	79	75	72
ASTM, Min	4	5	6
Under, Min	3	3	3
Thru, Min	9	11	13

Having determined that the 20 cps grade gave the fastest dry time of the three tested, this grade was used for further formulations.

c. Hydrocarbon Resin Vehicles, No Alkyd

The following hydrocarbon resins were tried in combination with chlorinated rubber for a rapid dry paint

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Neville, 685-125
Neville, Nevex 100
Neville, Nevchem 140
Neville, LX-1112
Hercules, Piccopale 100SF
Hercules, Piccotex 100

All the hydrocarbon vehicles turned dark amber after 2 months storage and were not considered further in this study. The raw material costs of paint made from hydrocarbon vehicles was about the same as that made from the present alkyd system so no economic advantage could be gained.

Dry times were satisfactory and a typical formulation is given in Table 5 using Hercules Piccopale SF100. The formula is cold cut, no cooking required.

TABLE 5

Pt 257	lbs/100 gals
Composition	
Piccopale, SF100	15
Safflower, Z4	20
Chlorowax 40	40
Parlon 5	125
MEK	133
225 Thinner	133
Toluene	62
6° Co Naphthenate	0.5
24% Pb Naphthenate	1.0
Epichlorohydrin	2.0
Exkin #2	1.0
Soya Lecithin	7.0
Bentone 38	4.0
95% Methyl Alcohol	2.0
TiO_2	50.0
T-70 Micro Cell	50.0
Talc	304.0
Vicron 45-3	304.0
Test Properties	
Vis, KU = 82	
ASTM, dry = 1 minute	
Under = 3 minute	
Thru = 8 minute	
Opacity = 0.91	
*Yellowness Index = 0.10	

*Increased to 0.15 after 2 months storage.

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d. Chlorinated Rubber Vehicles, No Alkyd

Non-convertible vehicles, with no driers for film polymerization were made using plasticized chlorinated rubber only. Without sufficient plasticizer these vehicles, although fast drying, are too brittle for practical use.

From the limited work done on these systems, the formula shown in Table 6 met the requirements for a rapid dry paint.

TABLE 6

	lbs/100 gals
Composition	
Alloprene, 20 cps	100
Chlorowax 40	75
Chlorowax 70	25
MEK	150
225 Thinner	150
Toluene	70
Epichlorohydrin	2
Exkin #2	1
Soya Lecithin	6
Bentone 38	6
95% Methyl Alcohol	2
TiO_2	100
T-70 Micro Cell	40
Talc	227
Vicron 45-3	227

Test Properties

Vis, KU = 79
ASTM Dry = 2 minutes
Dry Opacity = 0.95
Yellowness Index = 0.06
Dry Under = 3 1/2 minute
Dry Thru = 8 minutes

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This appeared to be a good formula with a reasonable raw materials cost and excellent drying characteristics but lack of time for field testing prevented a specification being written with this system. Further work is planned on this type of system.

e. Low Chlorinated Rubber - Alkyd with Fast Solvents

By using a minimum of chlorinated rubber with fast evaporating solvents, excessive top skinning of the paint film is retarded and with a pigmentation that allows the film to breathe, a satisfactory rapid dry system can be made. This is almost the reverse of our initial attempts in rapid dry formulation, where we relied on high levels to achieve the dry to no pick up time according to the ASTM method. For example, Pt 143 had a level of 173 lbs of chlorinated rubber per 100 gals of paint. The present rapid dry formula, which we consider only as a starting formulation, has a level of 80 lbs/ 100 gals of paint, and contains no toluene or slow evaporating solvents.

The lower chlorinated rubber level cuts the raw materials cost from $3.04/gal in Pt 143 to $2.10/gal for the Pt 400. About $0.20/gal in the Pt 400 is due to lower alkyd and chlorinated rubber costs but still a substantial savings is realized. Our present contract for the Pt 400 (white) is $3.00/gal in 55 gal drums delivered anywhere in California.

This type of formulation did not give the fastest ASTM drying time we have made, but did result in the fastest "Dry Thru" time, and even cold applied has shown excellent no-track times on the road.

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f. Formulas for Prototype Low Viscosity Rapid Dry Paint

The formulas for Pt 400 (white) and Pt 401 (yellow) prototype low viscosity rapid dry traffic line paint are shown in Table 7.

TABLE 7

Composition	lbs/100 gals Pt 400 (white)	Pt 401 (yellow)
Alkyd Resin, Reichhold P666-60	120	120
Chlorowax 40	40	40
Alloprene, 20 cps	80	80
Methyl Ethyl Ketone	150	150
Chevron 225 Thinner	150	150
Epichlorohydrin	2	2
Exkin #2	1	1
6% Cobalt Napthenate	0.5	0.5
24% Lead Napthenate	1.5	1.5
Soya Lecithin	4	4
Bentone 38	8	8
95% Methyl Alcohol	3	3
TiO_2, RANC-I	100	-
T-70, Micro Cell	40	40
Desertalc 54	240	247
Vicron 45-3	240	247
Medium Chrome Yellow	-	100
Test Properties		
lbs/gal	11.8	11.9
Non Volatile, %	69.8	70.2
Pigment, %	53.2	53.8
Viscosity, KU	80	80
ASTM D-711, Minutes	2	2
Dry under, Minutes	3	3
Dry thru, Minutes	6	6

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g. Field Trials with Prototype Rapid Dry Formula

Preliminary road tests were run with 200 gals of Pt 400, made by Pervo Paint Company, Los Angeles, California. With no heat and applied with air-atomized Binks 33 paint guns, the no-track times listed in Table 8 were obtained:

TABLE 8

SUMMARY OF TESTS USING Pt 400 COLD APPLIED

Dry Paint Thickness, (in.)	lbs Beads Per Gal Paint	Temperature °F Ambient	Temperature °F Surface	No-Track Time Seconds
0.003	2.8	88	107	20
0.004	1.5			30
0.006	2.5			45
0.006	3.0			45
0.005	2.8			30

With the California Hot Striper, using airless paint application and pressurized bead application, the results shown in Table 9 were obtained:

TABLE 9

SUMMARY OF TESTS USING Pt 400 - HEATED

Dry Paint Thickness, (in.)	Temperature of Paint	Temperature of Surface	Temperature of Ambient	lbs Beads Per gal Paint	No-Track Time Seconds
0.005	114	106	77	3.4	45
0.005	130			4.2	30
0.005	150			3.5	20
0.005	175			4.4	20

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It is interesting to note that the application of heat does not seem to greatly affect the dry time, hence this paint could be applied at ambient temperatures or heated to about 130°F if necessary when painting in heavily congested areas. This paint can also be applied at ambient temperatures through air atomized equipment used on some of our older striping units. During the colder winter weather some heat might have to be used to lower the viscosity, or if heat is not available, then additional thinner such as MEK could be used to lower the viscosity to a sprayable consistency.

3. Lower TiO_2 Levels

Interest in lowering the TiO_2 levels in traffic paint reached a peak during the TiO_2 shortage a few years ago when both price and availability were unknown from day to day. This resulted in a need to take a closer look at what was absolutely necessary and has resulted in a reduction in TiO_2 levels from 2 lbs/gal to 1 lb/gal in our present Rapid and Fast Dry Specifications.

a. Color Stability in Storage

TiO_2 levels of 0.5 lbs/gal were made with an alkyd-chlorinated rubber vehicle, and yellowness index observed after several months storage. A TiO_2 level of 1.0 lbs/gal is shown in Table 10 for comparison and also a 0.5 lb/gal level using a chlorinated rubber-only vehicle (no alkyd).

TABLE 10

TiO_2-YELLOWNESS INDEX

Vehicle Type	TiO_2 lbs/gal	Yellowness Index Original	2 months	8 months	16 months
Alkyd-Chlorinated Rubber	0.5	0.12		0.26	
" "	0.5	0.13		0.25	
" "	1.0	0.10		0.13	
" "	1.0	0.08			0.17
" "	0.5	0.10			0.27
Chlorinated Rubber No Alkyd	0.5	0.08	0.17		

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Due to the poor color stability with the 0.5 lbs/gal levels a minimum of 1.0 lbs/gal was set for present specifications.

b. Effect of Acrylic-Alkyd Copolymer and Acrylic Ester Vehicles

The Reichhold P666-60 alkyd used in our paint specifications was substituted with Reichholds' acrylic-alkyd co-polymer, Lustrasol 13-645 and part of the chlorinated rubber was substituted with Rohm and Haas' Acryloid B66, an acrylic ester resin. Much improved color stability has been observed with this combination, using low TiO_2 levels. Deleting the P666-60 alkyd and using a vehicle consisting of chlorinated rubber only or in combination with Acryloid B66 showed improved color stability indicating that the P666-60 alkyd probably contributes to most of the poor color stability. The formulations are listed in Table 11.

TABLE 11
VEHICLE COMPOSITIONS
lbs/100 gals Paint, all with 0.5 lbs TiO_2/Gal

Pt No.	P666-60	13-645	B66	Allo-prene 20	Chloro-wax 40	Chloro-wax 70	225 MEK	225 Thinner	225 Toluene
373	120	-	25	40	40	-	165	150	-
380	-	144	25	40	40	-	165	100	60
398	-	-	-	100	75	25	150	150	70
414	-	-	35	50	75	25	150	150	70

For test purposes, to accelerate any color changes, paints were made up with the above combinations and stored in an air circulating oven at 115°F for 1 month. Weekly checks were made of Reflectance and Yellowness Index. Results are shown in Table 12.

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TABLE 12

REFLECTANCE (R) AND YELLOWNESS (Y) INDEX

Time in Weeks	Pt 373 R	Pt 373 Y	Pt 380 R	Pt 380 Y	Pt 398 R	Pt 398 Y	Pt 414 R	Pt 414 Y
Original	86	.07	86	.07	87	.07	86	.07
1	83	.13	85	.08	86	.10	84	.09
2	82	.15	85	.09	85	.10	84	.11
3	82	.16	85	.10	85	.10	84	.11
4	81	.19	84	.10	85	.12	84	.11

R = Reflectance, 45°, Green Filter

Y = Yellowness Index, $\frac{\text{Amber-Blue}}{\text{Green}}$

The substitution of Acryloid B66 for part of the chlorinated rubber (Alloprene 20 cps) reduces the cost of the paint, since the B66 is about $0.62/lb compared with $0.75/lb for the chlorinated rubber.

The raw material costs for the above formulas were as follows:

Pt 373	$1.95/gal
Pt 380	2.03/gal
Pt 398	2.03/gal
Pt 414	1.85/gal

More work is required in this area before any specification formula can be written.

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FAST DRY TRAFFIC PAINTS

1. Lower Medium Chrome Yellow Levels

Chrome yellow levels of 2 or more lbs per gallon have been used for many years in yellow traffic paint. Recently, in an attempt to lower costs, the chrome yellow was reduced to 1.0 lbs/gal in the Rapid Dry paint and 1.3 lbs/gal in the Fast Dry type. Reduction in chrome yellow level causes little effect in the color produced and still meets Federal Color Standard 595 Color Number 13538. The weathering characteristic of chrome yellow to darken on exposure still persists with the lower levels. The chrome yellow level of 1.3 lbs in the Fast Dry will probably be reduced further to 1.0 lbs/gal if field tests prove satisfactory.

2. Uncalcined Diatomaceous Silica

Previous Fast Dry paints (Pt 225 and Pt 226) have used Johns-Manville synthetic calcium silicate, Micro-Cell T-70 which was used because of its excellent suspending properties, whiteness and prime pigment extending ability. It replaced the flux calcined diatomaceous silica, Celatom 281 or Eagle-Pichers' MW27, which gave very poor anti-settling properties in previous formulas Pt 145 and Pt 146. The raw material cost of the T-70 is about $0.20/lb which at a 40 lb/100 gal loading represents a cost of $0.08/gal paint. A non-calcined naturally occurring diatomaceous silica, Aquafil K-8, at $0.032/lb, produced by Cyprus Mines at Fernley, Nevada, was tried but the greyish color produced lower reflectance readings in the white Fast Dry formula. However, when substituted for the T-70 in the yellow formula, no difference in color could be detected. Providing it continues to produce no anti-settling problems, its use in the yellow traffic Fast Dry will be continued. This means a savings of about $0.06/gal paint. Slightly slower

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solvent release was noticed when the K-8 was used in the Rapid Dry (Pt 401) formula, so at present the Micro-Cell T-70 is still used in the Rapid Dry yellow.

3. Revised Fast Dry Traffic Paint Formulas.

The Fast Dry formulas are detailed in Table 13 and represent changes only in the chrome yellow amount and the use of Aquafil K8 in the yellow. The required lbs of each material have been formulated to whole numbers and amounts called for represent whole bag weights where possible, for example K-8 is in 50 lb bags and T-70 comes in 40 lb bags.

TABLE 13

Formulas for Fast Dry Paints

	lbs/100 gals	
	Pt 361 (white)	Pt 362 (yellow)
Alkyd Resin, Reichhold P666-60	130	130
Chlorowax 40	50	50
Chlorowax 70	25	25
Alloprene 20 cps	60	60
Methyl Ethyl Ketone	100	100
Chevron 250 Thinner	140	140
Toluene Substitute, Chevron 51-L	60	60
6% Cobalt Napthenate	0.7	0.7
24% Lead	1.5	1.5
Epichlorohydrin	2.0	2.0
Exkin #2	1.0	1.0
Bentone 38	8.0	8.0
95% Methyl Alcohol	3.0	3.0
Soya Lecithin	4.0	4.0
TiO_2, RANC-I	100	-
Desertalc 54	220	210
Micro-Cell T-70	40	-
Vicron 45-3	220	210
K8, Aquafil	-	50
Chrome Yellow Medium	-	130
<u>Constants</u>		
lbs/gal	11.7	11.7
Non volatile, %	69.1	69.6
Pigment, %	50.5	51.3
Viscosity, KU	72	72
ASTM-D711, Minutes	5	5
Dry Under Minutes	5	5
Dry Thru Minutes	10	10

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SUMMARY OF CONTRACT COST PRICES FOR RAPID AND FAST DRY PAINTS

Table 14 shows a tabulation of competitive bid prices for Rapid and Fast dry paints starting with the first rapid dry, Pt 97 white and Pt 98 yellow. The higher priced pigment and vehicle components such as chlorinated rubber, TiO_2 and chrome yellow are given to show how these have been decreased to reduce cost and to accommodate some material shortages. None of these decreases have been detrimental to the performance of the paint. It is to be noted that the price increases during 1974 even with lower levels of chlorinated rubber and TiO_2 can be attributed to the sharp rise in raw materials cost during the so-called energy shortage of 1974, a period with allocations, shortages, price fluctuations and general high prices for all raw materials.

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TABLE 14

Paint No. Rapid	Paint No. Fast	lbs/100 Gals Paint Chlorinated Rubber	lbs/100 Gals Paint TiO_2	lbs/100 Gals Paint Chrome Yellow Medium	*Bid Price $/Gal	Year
Pt 97		165	200		2.91	1973
Pt 98		167		218	3.10	"
	Pt 145	82	150		3.88	1974
	Pt 146	82		240	4.75	"
Pt 143		173	150		4.36	"
Pt 148		176		220	5.03	"
	Pt 225	56	100		3.09	"
	Pt 226	56		200	3.87	"
	Pt 226M	56		130	3.64	1975
Pt 400		80	100		2.95	"
Pt 401		80		100	3.08	"
	Pt 361	60	100		2.80	"
	Pt 362	60		130	3.04	"
Pt 400		80	100		2.72	1976
Pt 401		80		100	2.79	"
	Pt 361	60	100		2.62	"
	Pt 362M	60		100	2.72	"

*Prices quoted are delivered in 55 gal drums, palletized, 1976 prices include lined drums. Prices are based on competitive bidding from 4 to 6 vendors.

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FLAME SPRAY STRIPING GRANULES

A performance type specification has been written for thermo applied, flame spray striping granules of which several thousand pounds were used annually for crosswalk and legend marking. This material will bear traffic within 10 seconds. The usage has decreased lately because of high cost of material.

The Laboratory developed a successful formula using solid polyamide resins. However, it was decided to develop a specification based upon Laboratory performance tests. Considerable work was required to determine what properties needed to be considered and to set the specification limits for each property.

Tests indicate that the wear of the granules is about the same per mil of thickness of traffic marking applied to the road as that of conventional traffic paints. However, the rapid dry feature and ease of application justifies the use of the striping granules in some applications despite the higher cost.

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CONCRETE CURING COMPOUNDS

Prior to 1967, the curing compounds used on State of California highway construction were required to meet a modification of AASHTO specification M-148, a performance type specification. The material furnished by manufacturers at that time was the so-called wax-base curing compound. This product consisted of slack wax, a by-product of petroleum refining, dissolved in kerosene or mineral spirits,. Clear curing compounds, for visibility during application contained fugitive dyes. Pigmented curing compounds contained white or gray pigments.

It was found that the clear wax-base compounds performed reasonably well, but that variations between batches of slack wax and temperature variations during storage caused hard pigment settling and extreme variations in water retention test results of pigmented curing compounds.

The Office of Structures did not permit the use of curing compounds on bridge decks at that time. Bridge decks were moist-cured using wet mats.

Between 1967 and 1970, under a State financed project, formulation type specifications were developed for two relatively low cost pigmented curing compounds to supersede the wax-base material. The first was a petroleum hydrocarbon resin based formulation containing limed wood rosin, and the second contained a lower cost petroleum hydrocarbon resin without the limed wood rosin.

The Office of Structures had in the meantime started using Federal specification No. TTC-00800, a chlorinated rubber-base concrete curing compound on bridge decks. The material was being purchased for about five dollars per gallon. Under the State-financed project, a specification for chlorinated rubber curing compound was developed costing approximately half as much as the federal specification material.

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In the period from 1970 to 1975, development and modification of curing compound formulations continued under Federal funding. The formulation-type specifications for concrete curing compounds now used by Caltrans were developed between 1970 and 1972 as modifications of existing specifications. The changes were made in response to reduced availability of certain raw materials and to complaints about the performance of curing compounds in some field applications.

The 1975 California Standard Specifications contain formulations for a pigmented petroleum hydrocarbon base and three chlorinated rubber base curing compounds. Specification number 721-80-71, pigmented petroleum hydrocarbon resin base curing compound, is recommended for general use including pavement, curbs, gutters, and sidewalks. This formulation was developed to supersede two earlier products when manufacture of the specified titanium - calcium pigment was discontinued. Use of titanium dioxide pigment with whiting and mica as extenders produced a compound having excellent anti-settling properties.

Pigmented, chlorinated rubber-base curing compound, specification number 721-80-100, is recommended for use on bridge decks and structures where rapid drying and resistance to abrasion during the concrete curing period are important considerations. This formulation was developed when environmental considerations made it necessary to find a substitute for chlorinated biphenyl resin as a plasticizer for chlorinated rubber. Another pigmented, chlorinated rubber formulation, specification number 721-80-101, is recommended for median barriers and other vertical surfaces where it is desirable to use the curing compound both for curing and as a durable, aesthetic coating. Specification number 722-80-102, the clear, chlorinated rubber curing compound is recommended for median barriers, exposed aggregate concrete and other surfaces where aesthetic considerations preclude the use of pigmented curing compound.

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From 1972 to 1975, curing compound research was directed toward reducing costs, improving resistance to yellowing, and developing water-base products. Since the pigmentation in pigmented chlorinated rubber curing compound 721-80-100 is relatively pure titanium dioxide, partial substitution with various extender pigments was tried in an effort to lower pigment costs without reducing hiding power. Water retention test results for chlorinated rubber curing compound were adversely affected by partial replacement of titanium dioxide pigment with extender pigments. Extenders which were tried included calcium silicate, mica, talc, and clays.

It was found that the use of talc as a substitute for mica in the petroleum hydrocarbon resin compound could be permitted. No adverse affect on reflectance, settling, or water retention was produced by the substitution.

Several ultra violet absorbers and anti-oxidants were added to chlorinated rubber formulations in an effort to reduce yellowing under weathering. The inhibitors tested produced no significant reduction in yellowing.

Since both petroleum hydrocarbon resin and chlorinated rubber curing compounds yellow somewhat under weathering, acrylics and other resins have been studied as possible replacements. A styrene-acrylate formulation showed less yellowing than chlorinated rubber, but it had poor water retention characteristics and cost nearly as much for raw materials as the chlorinated rubber compound. Acrylics showed excellent resistance to yellowing in the Weather-o-Meter. Whether emulsified in water or dissolved in organic solvents, acrylic resins tested to date have failed to produce satisfactory curing compounds (water losses in the water retention test have been too high). To date no completely satisfactory non-yellowing curing compound has been formulated.

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Pending the development of a non-yellowing clear curing compound with good weathering resistance at lower cost than the clear chlorinated rubber formulation, use of AASHTO specification M-148, Type 1, clear has been permitted. This material, usually furnished as a non-pigmented wax-base material "weathers" off the concrete completely after a few months exposure. There is still some interest in developing a weather-resistant clear compound that will produce the "wet look" desired by architects for exposed aggregate concrete.

Because of increasingly stringent air pollution control regulations controlling the use of organic solvents, the Transportation Laboratory staff has been trying to develop specifications for water base paints and curing compounds. While a commercial water base curing compound containing linseed oil was satisfactory, no other water base linseed oil, petroleum hydrocarbon resin, latex or acrylic formulation tested or made at the Transportation Laboratory meets our water retention requirements.

Because of the slowed pace of highway construction and the relatively greater importance of environmental and maintenance-oriented projects, research on the development of curing compound modifications has been given relatively low priority. Development in this field is expected to proceed at a slackened pace.

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MISCELLANEOUS PAINTS

1. Primers for Steel

Several systems were evaluated under this project, inorganic zinc primers, organic zinc primers and an organic chromium alkyd primer. All prospective paint systems were first evaluated by use of salt spray ASTM Method B117-23. Those systems that indicated good corrosion inhibitive properties were then further evaulated by placing test panels at a coastal exposure site for a long term test. A full size box beam sign structure located at the Laboratory was also used for further evaluation of test coatings. To make the test sign more realistic a vibrator was installed to simulate road vibrations, and a water spray attached to simulate fog or high humidity.

Preliminary results from the salt spray tests indicated that the inorganic zinc, organic zinc and the organic chromium alkyd primers all had good corrosion inhibitive properties. All coastal exposure tests, within the time allowed for evaluation, also showed good properties when applied at a dry film thickness of 3-4 mils over fresh well sand-blasted steel. The coatings applied to the box beam sign at the Laboratory generally performed well even when the steel surface was poorly prepared in an attempt to evaluate the degree of blast cleaning that was necessary for good performance. One failure occurred because an excessively thick application of inorganic zinc resulted in mud cracking of the paint film. The inorganic zinc rich primer, when used in full scale contract application to box beam signs, however, did not exhibit the same successful performance as when applied under laboratory controlled applications. A number of the sign structures showed signs of severe corrosion and loss of adhesion less than two years after erection. In some cases failures were visible even before the structures were erected. No clear cut explanation can be made for the field application failures when the primer had performed so well in all

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previous laboratory tests. One theory was that failures were due to poor surface preparation and application. Attempts to duplicate the failures at the Laboratory were not successful. The corrosion areas on some structures have since been sand blasted to bare steel and repainted with a single package organic zinc similar to the one currently being specified; these areas are still in good condition after five years.

Further test applications of selected paint systems were made on sections of the Leffingwell Creek Bridge in May 1971 utilizing zinc rich paints. This bridge is on Route 1, just north of the town of Cambria in a severe marine environment. It has been used for many years for the evaluation of coating systems and has been previously described in detail in Research Report 645135, dated January 1969.

Blast cleaning and coating the test sections was done by the members of the Chemical Unit of the Transportation Laboratory and by Bridge Department Paint Inspectors. Five systems have been applied on previous tests and described in the 1969 report.

The following additional coating systems were applied to the test section:

System 6. Four mils of Koppers Organic Zinc Primer corresponding to State Specification 691-80-62, a single package system. The binder in this coating is Union Carbide Phenoxy PKHH Resin, a long chain condensation product of epichlorohydrin and Bisphenol A, having no terminal epoxy groups. Part of this primer was top-coated with vinyl wash primer, State Specification 701-80-52 as a barrier coat followed by 2 mils of vinyl aluminum coating, State Specification 702-80-49. The object of topcoating with a vinyl was to determine how much added protection would be provided to the organic zinc coating.

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System 7. Four mils of Zinc Lock, State Specification 702-80-56, an inorganic ethyl silicate vehicle-zinc dust system comprising two packages which are mixed in the proper proportions just prior to use. Part of this system was overcoated with vinyl wash primer and two mils of vinyl aluminum for the reason described in System 6.

System 8. Four mils of Dimetcote 5, an inorganic potassium silicate water based vehicle-zinc dust system comprising two packages which are mixed in the proper proportions just prior to use. Part of this system was overcoated with vinyl wash primer and two mils of vinyl aluminum finish coat for the reasons described in System 6.

After nearly five years of exposure the various primer systems that were not top-coated show no rust or corrosion. However, the areas that were top coated show varying degrees of corrosion and breakdown indicating that the top coats do not provide extra protection, but under these conditions appear to be detrimental to the life and protection of the steel by the primer.

As the project progressed, because of the problems experienced with the inorganic zinc primers and the fact that the production of the organic chromium pigment was discontinued by the manufacturer, primary emphasis was placed on developing a compositional specification for an organic zinc rich primer that could be used to give good protection to steel structures statewide. During the course of this project, the inorganic zinc primers were dropped and the current specification for the organic zinc primer, 741-80-62, was adopted.

Evaluation of various types of binders, zinc powders, zinc: binder ratios, and suspending agents continued. Thirty-two formulations of organic zinc rich primer for steel structures were made and

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tested. These primers all have a vehicle resin prepared from a condensation product of bisphenol A and epichlorohydrin, having a molecular weight of approximately 30,000 and with no terminal epoxy groups. The primer formulations and their properties are shown in Table 14.

Evaluation of the various formulations that have been made, suggests that the existing formulation could possibly be improved by using a zinc with low calcium oxide content, making solvent modifications to lower the flash point, limiting the specification to allow the use of less reactive suspending agents, and by utilizing a slightly lower pigment to binder ratio. Further formulation and testing work would be required before writing a new specification.

2. Vinyl Wash Primer

A study was made of vinyl wash primer, Federal Specification MIL-C-15328A and later revisions to provide proper spray application. From our experience we believe ideal viscosities for wash primers are in the range of 57-67KU.

Therefore, a State Specification was written, based essentially on Federal Specification MIL-C-15328A, allowing only ethyl alcohol along with the prescribed butanol, or a combination of ethyl and 99% isopropyl alcohol with butanol. It is readily perceived that the lower molecular weight aliphatic alcohols (ethyl) will provide greater solubility because of the higher hydroxyl content and lower viscosity.

3. Primers for Galvanized Steel

Additional work that has been done during the project includes work on primers for galvanized steel. Five panels of galvanized

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corrugated sign fascia were painted with the following primers and exposed on the Laboratory sign rack in Sacramento:

1. Calcium Plumbate
2. Acrylic Latex
3. Zinc-Zinc Oxide, Federal Spec. TT-P-641 Type II
4. Zinc-Chromate, State Spec. 701-80-51
5. Vinyl Wash Primer State Spec. 701-80-52

These primers were applied after alkali detergent washing, and rinsing of the galvanized panels. The primers were coated with tinted alkyd top coats.

After more than three years exposure, tests were made to determine the relative adhesion values of the primers to the galvanized metal surface. Readings, taken with an Elcometer Adhesion Tester, are listed in Table 15:

TABLE 15

ADHESION OF PRIMERS TO GALVANIZED STEEL

	PRIMER	ADHESION lbs/in^2
1.	Calcium Plumbate	Less than 50
2.	Acrylic latex	100
3.	Zinc-Zinc Oxide	200
4.	Zinc Chromate	50
5.	Vinyl Wash Primer	100

As a result of this study, California Standard Specifications now require galvanized surfaces to be coated with Zinc Dust - Zinc Oxide primer meeting Federal Specification TT-P-641, Type II, prior to painting.

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4. Equipment Enamel

A specification was developed for a rapid dry styrenated alkyd orange equipment enamel for use on highway department automotive equipment. The conventional TT-E-489 alkyd type enamel which has been used for about 20 years, dries too slowly with resultant lost time in the use of vehicles. The new specification styrenated alkyd coating will dry sufficiently in 20 minutes to enable the vehicles to be placed in use.

The cost of the new enamel is one-half the cost of the older proprietary enamel which had no better properties. The State Specification for the new enamel is 711-80-151.

5. Waterbase Paints

Following are the results of tests made on various waterbase paints received in the laboratory. The four paints tested were:

S-633	Borden Corporation	SCV24-2370
S-679	Rohm & Haas Corporation	F271C Type
S-680	Rohm & Haas Corporation	F271C Type
S690	Andrew Brown Company	"Wrap 5"

Generally, the performance of these paints is no better than that of paints now used by the State, usually not as good. However, in some instances, the paints tested did show some promise.

The first series of tests were wet adhesion tests run according to Federal Test Method No. 141 Method 6301. When painted over bare steel, sample S-690, a water reducible coating, did not lose adhesion. All others became loose in varying degrees. As controls, a panel each of Primer, Basic Lead Silico-chromate, 701-80-83, and an alkyd finish paint, 701-80-82, were also tested. Neither of the controls passed the test; however, they are never used in the field without a vinyl wash primer over bare steel or over the zinc primer, 721-80-62.

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One observation that may be of some value was the total lack of rust in the scribed lines of Panels S-633 and S-690.

Further adhesion tests were made with the test paints applied over a surface of Organic Zinc-Rich Primer, 721-80-62. None of the materials passed this test, including the control alkyd finish. Sample S-633 fared the best; failure appeared to be more a film cohesion loss than failure to adhere to the substrate.

The final adhesion test was on zinc-primed surface overcoated with 0.5 mil of vinyl wash primer, 721-80-52. All samples, except S-633, and the alkyd control passed this test. Sample S-633 failed in adhesion. These results again verify the advantage of a vinyl wash prime coat for adhesion.

The next test consisted of applying the paints to bare steel under very humid conditions (outdoors under cover, it was raining). The prepared panels were allowed to cure outside, then scribed and placed in a 100% humidity room for one week. Upon removal, Sample S-680 had numerous rust spots over the face of the panel. The other three samples were satisfactory. Additionally, sample S-633 had no rust in the scribe lines and S-690 had only a few traces of rust in the scribes.

The next test was similar to the previous except the panels were coated under laboratory conditions and cured approximately one week at 25°C and 50% relative humidity. These panels were then scribed on the lower half and placed in the fog room for one week. After this time, the panels exhibited almost identical results as those of the previous test. A control panel of silico-chromate primer, 701-80-83, had rust on the scribe lines but no other film flaws. The panels were then returned to the fog room for a total exposure time of 500 hours.

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At this time the panels appeared to be in not much different condition than at 168 hours. Samples of S-633 and S-690 had definite rust in the scribe lines, the other samples and the control had more rust than at 168 hours.

After stripping, the control panel had fairly sharp scribe lines with no indication of undercutting. There was no corrosion beneath the film. When originally stripped, the panel was clean. All the test samples had underfilm corrosion evidence and undercutting in varying degrees along the scribe lines.

The final test was to expose prepared panels to a 5% salt spray. After 500 hours exposure, the sample panels were almost completely covered with rust and corrosion. When stripped, there was extensive underfilm corrosion. The control panel was severely corroded beneath the scribe lines. Also, the film had lost adhesion away from the scribe lines for approximately 0.5-inch on either side of the lines. However, except for this, the face of the panel appeared satisfactory.

In conclusion, it appears that water-based paints may be of some value in environments other than marine exposures. They still do not quite match the performance of regular solvent based paints.

A specification for a tinted translucent acrylic emulsion, Specification No. 741-80-15, was prepared to be used as a contrast coating for exterior concrete or masonry surfaces. This material is a water base system made from a 100% acrylic copolymer and is to be used as a replacement for the phenolic base spar varnish that yellows, cracks, and flakes off after a relatively short period when exposed to sunlight.

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ANTI-SCALING TREATMENTS FOR CONCRETE

This phase of the project was undertaken in response to a request from the Division of Maintenance and Operations for evaluating waterproof coating and surface treatments. Deicing chemicals applied to bridge decks during frost prevention and snow-removal operations are splashed onto the railings by highway traffic. In contact with deicers, which are usually chloride salts, non-air entrained portland cement concrete scales and deteriorates under the influence of freeze-thaw cycling.

We had hoped to find, among the five concrete surface treatments suggested by various people within Caltrans, a material suitable for field testing on bridge railings during the winter of 1974-75. A suitable treatment would be expected to prevent scaling and/or arrest active scaling of portland cement concrete exposed to deicing salts for at least 50 cycles of freezing and thawing.

The test specimens and test procedures as outlined in ASTM Designation: C-672 were used for this evaluation, with the exception that 4% sodium chloride solution was used in lieu of calcium chloride solutions. Table 16 shows the concrete mix designs used in preparing test specimens.

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TABLE 16

CONCRETE DESIGNS FOR SCALING TESTS

7-sack mix: Fabricated 3-6-74	52% Rock: 1x3/4 - 23% 3/4x3/8 - 52% 3/8x#4 - 25%	
	48% Sand: As Received	
	Unit Weight	144.15 pcf
	Slump	2-1/2"
	Air Content	4.8%
	Cement Factor	6.90
	Water Cement Ratio, SSD	52.3
6-Sack mix: Fabricated 3/6/74	52% Rock: 1x3/4 - 23% 3/4x3/8 - 52% 3/8x#4 - 25%	
	48% Sand: As Received	
	Unit Weight	149.24 pcf
	Slump	2-1/2"
	Air Content	1.5%
	Cement Factor	5.98
	Water Cement Ratio, SSD	58.9
5-sack mix: Fabricated 4,5,6, 1974	52% Rock: 1x3/4 - 23% 3/4x3/8 - 52% 3/8x#4 - 25%	
	48% Sand: As Received	
	Unit Weight	141.71 pcf
	Slump	3"
	Air Content	6.6%
	Cement Factor	4.90
	Water Cement Ratio, SSD	69.0

The slabs were cured by wet burlap overnight and stripped the next day. They were placed in the fog room for the remainder of the 14-day cure period. They were then placed in an oven at a temperature of 235° to dry for 3 or 4 days. They took about 5 hours to cool in lab air, then they were sealed in plastic bags and stored in the 50% room.

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The following treatments were tested:

1. Chlorinated rubber paint, PG. 120, experimental paint made at the Office of Transportation Laboratory.

2. Boiled linseed oil + kerosene combined at a 1:1 ratio (by volume).

3. Houston No. 2 Waterproofing Preservative, liquid.

4. Thompson's Water Seal, Heavy Duty, No. 201, liquid.

5. Xypex Concentrate plus water mixed at a 5:1 ratio (by volume), a mortar-like material.

In addition, untreated six-sack, non-air-entrained concrete specimens were tested as controls in comparison with 5-sack and 7-sack air-entrained concrete.

After 10 freeze-thaw cycles the treatments were placed on half of the partially scaled surfaces of some control specimens to evaluate their effectiveness in halting or retarding further scaling.

Another set of specimens was prepared and placed outside, in Sacramento, to evaluate the resistance of the coatings to weathering effects of sunshine, fog and rain.

The test results, shown in Table 18, indicate that either air-entrainment or increased cement content retards but does not prevent freeze-thaw/salt scaling. Among the surface treatments tested, boiled linseed oil in kerosene was the most effective in limiting scaling and checking the deterioration of previously scaled concrete. No treatment entirely prevented salt scaling under freeze-thaw cycling.

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Natural weathering caused blistering of the chlorinated rubber paint and alligator cracking and flaking of the Xypex.

The following observations may be made concerning the effects of the anti-scaling treatments on the esthetic appearance of concrete:

1. Both the Xypex and the chlorinated rubber paint were unsatisfactory. (The Xypex flaked off and the chlorinated rubber blistered and chipped.)

2. The Houston and Thompson's liquids did not alter the appearance of the concrete.

3. The linseed oil-kerosene treatment darkened the concrete slightly, but did not otherwise adversely affect its appearance.

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CONTINUING RESEARCH ON COATINGS

There is a need to continue research and development work on coatings for highway use in order to develop satisfactory products. Other factors contributing to this need include continued inflation of materials and labor costs, changing paint technology, and shifting transportation priorities. We shall continue developing paint specifications, but the emphasis will shift more to materials for use in highway maintenance and in alternate modes of transportation.

Two new projects on traffic line paints, "Low Heat, Rapid Drying Traffic Paint with Improved Bead Retention", Item D-5-53 and "Develop and Evaluate a Substitute for Chrome Yellow in Yellow Traffic Line Stripes", Item D-5-51 have received FHWA approval. A proposal entitled "Water Base Coatings for Protection of Steel Structures" has been submitted for approval, and another proposal, "Improvement of the Performance of Zinc Rich Primer" is being prepared.

Research on coatings for concrete, alternate types of concrete curing materials, and performance specifications for coatings are included in our proposed five year research budget. This work is expected to start in fiscal year 1979-80.

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REFERENCES

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3. Rooney, H. A., and Woods, A. L., "Evaluation of Coatings on Coastal Steel Bridges 16 Year Period". No. M&R 645135.

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